On-Scene Analysis/Forecast System

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LONG TERM GOALS

Develop and demonstrate an end-to-end, on-scene analysis/forecast system for real-time data fusion, analysis, and forecasting. This system will be used to produce tactical atmospheric parameters that affect weapon and sensor systems and will be designed to use a local area network interfaced to automated instruments, a modern database, and supporting software.

OBJECTIVES

Develop the framework for an analysis, nowcast, and short-term forecast system that can be used at on-scene locations. This development will include optimal objective analysis methods that blend all observations and dynamical constraints into a 3-dimensional depiction of the atmosphere; methods to include new data sources (e.g., in-situ, remotely sensed observations) into existing analysis methods; quality control methods for on-scene observations to insure time and space continuity; initialization procedures to reduce high-frequency oscillations resulting from initial imbalances of analyzed data; a procedure for flexible and efficient execution of inner grids (e.g., starting time, location); and a hierarchy of physical parameterizations that allow a choice between computational time and sophistication. The performance of the system will be evaluated, and studies will be performed to determine the impact of simplified model physics and/or code optimization to meet time constraints.

APPROACH

Our approach is to use the atmospheric component of the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) as the framework for the on-scene system. Modifications and/or additions to this system for on-scene applications include:

1. Build an atmospheric data assimilation system that will be able to analyze mesoscale weather by applying sophisticated analysis procedures capable of ingesting the information from conventional and non-conventional observations.

2. Develop general algorithms to allow for portability of COAMPS between hardware platforms, including both shared and distributed memory systems while maintaining high performance on each platform within one single-code version of the system.

3. Build alternative physical parameterization packages to allow timely short-term forecast for on-scene computer systems. Develop procedures to allow flexible execution of inner high-

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**
4. TITLE AND SUBTITLE **On-Scene Analysis/Forecast System**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Monterey,CA,93943-5502**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

resolution grids at delayed starting time and allow multiple nested domains at the same level of grid configuration.

4. Link the analysis and forecast model output to METOC decision aids via the Tactical Environmental Data Subsystem (TEDS) data base, a component of the Tactical Environmental Support System/Next Century (TESS/NC), that provides the network interface to tactical computer systems.

5. Develop a “warm start” capability for COAMPS to begin the local data assimilation cycle from COAMPS forecast products produced at another remote center.

6. Use the developed system to conduct case studies of relevant meteorological phenomena.

WORK COMPLETED

COAMPS has been interfaced with the Multivariate Optimum Interpolation (MVOI) objective analysis, a univariate objective analysis of temperature and moisture, and a system-independent database. This system has been run in a data assimilation mode using up to seven nested grid configurations over numerous limited-area domains over the earth.

The MVOI objective analysis procedure of COAMPS had been updated to include the water-vapor winds and cloud-track winds into the analysis. The system now includes initialization procedures such as digital filter and dynamic initialization to remove high-frequency oscillations that result from imbalances in the analyzed fields. The dynamic initialization will digest, in the future, in-situ and remotely-sensed data through reversed physical parameterization(s).

A generalized script file was designed to execute COAMPS in different environments on different platforms. The on-scene users can easily modify the codes, and compile and generate executables on their local computer system. COAMPS has been ported to various workstation environments and tested with differing number of processors. Some algorithms of the system have been found to use cache memory inefficiently while others exhibit poor scalability. Modification of the algorithms was made to alleviate some of these problems by reducing the length of long loops that involve many two- and three-dimensional arrays to reduce the cache conflict problem. Further restructuring of some algorithms will be carried out in the future. A diagnostic package was completed for post-analysis that can be tailored easily for on-scene needs.

The configuration of COAMPS has been upgraded to allow multiple nested grids at the same level. This allows a centralized site to provide analysis and short-range forecasts for different small regions simultaneously. The system also allows capability of flexible starting time of the inner grids.

The Kuo-type cumulus parameterization scheme has been implemented as an option in COAMPS. The Kain-Fritsch scheme was updated for faster execution time and improved representation of physical effects. A simplified radiation scheme was coded and implemented that considers the radiation effect to the terrain temperature only. The execution time for the simplified radiation scheme is negligible compared to the full radiation scheme.

RESULTS

The upgraded COAMPS was successfully ported to a variety of workstations and the results have been verified against the operational FNMOC version of the code. The improved portability assures code consistency and maintainability across platforms.

The capability of running multiple nested grids at the same level allows the on-scene system to provide analysis and short-range forecasts for several different regions at the same time. The capability of a delayed starting time for the inner grids reduces the executing time substantially, depending on the difference between the initial time of the outer grids and the starting time of the inner grids. Modification of the code and compiler options leads to an improvement of 31% in the throughput of COAMPS application. The diagnostic package allows shipboard users the flexibility of designing and examining desired parameters for post analysis.

The impacts of including water vapo-tracked winds in COAMPS analysis was tested with Hurricane Opal case in 1995. Over the ocean where no radiosonde observations are available, the water vapor-tracked winds provide much better structure of the cyclone at upper levels. There is a 6% improvement of the 48h forecast position errors with water vapor-tracked winds included. It is anticipated that including remote-sensed data will enhance analysis for shipboard applications.

COAMPS was tested for a week-long series of 24h forecasts in January 1998 over Europe. These tests utilized two levels of nesting with 81 and 27 km resolution to test the performance of Kuo cumulus parameterization scheme against the Kain-Fritsch cumulus parameterization. The average speed up of the computation time for the cumulus parameterization is 55% and the average memory saving is 7% by using the Kuo cumulus parameterization. The statistics of the 24h forecast in terms of the bias and RMS indicated that the geopotential height of the runs using the Kuo scheme has slightly larger errors than the one using Kain-Fritsch, while the temperature and wind speeds for both types of runs are similar. This result indicates that for short-range forecasts, the system can gain substantial computational efficiency using the Kuo scheme without losing much accuracy of the forecast for parameters of more local interest, such as wind and precipitation.

The simplified radiation package was tested with one case in October 1995. Preliminary results indicate that the 24h forecast sea-level-pressure pattern generated by COAMPS shipboard version using the simplified radiation scheme is similar to the one using the Harshvardhan scheme, with one to two millibar differences in the high and low pressure centers. More extended comparison are underway.

IMPACT

The success of COAMPS in the on-scene environment is significant and has been recognized by CDR David G. Markham as "… a monumental achievement that will undoubtedly have a far-reaching impact on our future METOC CONOPS." The continued effort on the improvement of the system to allow assimilation of in-situ and remote-sensed data, and initialization procedures to remove initial imbalances, more flexible execution capability, and a more efficient forecast model, will warrant successful application of the on-scene system to provide timely atmospheric conditions for Navy missions.

TRANSITIONS

Developments from this program transition to an existing 6.4 program (PE 0603207N) for applications within TESS/NC and, via the TESS/NC - JMCIS link, with the tactical applications supporting on-scene decision-makers.

RELATED PROJECTS

Related 6.2 projects within PE 0602435N are BE-35-2-18, for the development of atmospheric mesoscale models, BE-35-2-19, for the development of data assimilation techniques, BE-35-2-21, for the development of advanced visualization techniques, and T045-99, an effort to understand and develop better moisture, cloud, and precipitation forecasting techniques. The related 6.4 project under PE 0603207N is X2343-10, which focuses on the transition of the 6.2 development to the STAFC demonstration project.

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